State Of The Art (SOTA)
Manual For Non-Hazardous Onsite
Remediation Processes

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State of the Art (SOTA)
Manual for Non-Hazardous Onsite Remediation Processes
Section 3.10

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3.10.ii: ABBREVIATIONS

AST	Air Stripping Tower
BACT	Best Available Control Technology
CFR	Code of Federal Regulations
CH_4	Methane
CO	Carbon Monoxide
gr/dscf	Grains Per Dry Standard Cubic Foot
HCl	Hydrogen Chloride
LAER	Lowest Achievable Emission Rate
LTTD	Low Temperature Thermal Desorber
MACT	Maximum Achievable Control Technology
NESHAP	National Emission Standards For Hazardous Air Pollutants
NO_x	Nitrogen Oxide(s)
O_2	Oxygen
ppmv	Parts Per Million By Volume
ppmvd	Parts Per Million By Volume, Dry Basis
SO_X	Sulfur Oxide(s)
SOTA	State Of The Art
SVES	Soil Vapor Extraction System
VOC	Volatile Organic Compound

3.10 STATE OF THE ART MANUAL FOR NON-HAZARDOUS ONSITE REMEDIATION PROCESSES

3.10.1 Scope

The purpose of this manual is to publish State Of The Art (SOTA) performance levels for equipment used to process non-hazardous wastes, or waste by-products, generated from industrial on-site dumping, or discharges to on-site soils or ground water. Remediation technology included in this scope are:

A. soil vapor extraction systems (SVES);
B. air stripping towers (AST)other groundwater treatment equipment;
C. low temperature thermal desorbers (LTTD);
D. exsitu aerobic treatment systems; and
E. tank cleaning and degassing

NOTE:
Sites containing hazardous waste, pursuant to N.J.A.C. 7:26G-5, are not covered by this manual. These sites have unique characteristics. They will be reviewed and evaluated on a case-by-case basis. To obtain information on waste classification, please call the Bureau of Advisement and Manifest, New Jersey Department of Environmental Protection at 609-292-8341.

3.10.1.1 Soil Vapor Extraction Systems

SVES is an insitu remediation technology for removing volatile organic compounds (VOC) from unsaturated zone soils, primarily by mass transfer and volatilization. SVES consists of using a vacuum blower to extract soil gas from soils containing the VOC through a series of vertical and/or horizontal extraction wells. Extraction can be done continuously or in cycles. The induced vacuum causes VOC to volatilize and subsequently be removed from the unsaturated zone soils. Typical duration of this technology is one to two years, but operation occurring up to five years is not uncommon.

Dual phase recovery is a derivative of a SVES. Here, liquid and vapor phases are extracted simultaneously from horizontal and/or vertical wells which are below the soil surface. The liquid phase is separated from the vapor phase with the use of a knock out drum or similar device. The cumulative impact of the air contaminant emissions from the treatment of the liquid and vapor streams are evaluated concurrently.

NOTE: If SVES occurs simultaneously with biosparging and a higher volumetric air stream is withdrawn from the soil than is charged to the soil, then the SVES SOTA performance levels apply.

3.10.1.2 Air Stripping Towers and Other Groundwater Treatment Equipment

Air stripping is an exsitu groundwater treatment technology for removing VOC from groundwater by mass transfer and volatilization. The basic principle of this technology is to strip VOC from groundwater by enhancing the contact between air and VOC contaminated groundwater. A counter-current packed tower is the most common form of air stripper employed and consists of charging the contaminated groundwater at the top of the tower while ambient air is forced into the bottom of the tower. This causes the VOC to transfer from the liquid phase in the groundwater to the vapor phase in air, and be exhausted out of the tower. The packing material, which can be, but is not limited to, Raching rings, Tellerettes, or Saddle rings, enhances the contact between air and groundwater by providing surface area. Other types of air strippers include tray scrubbers, venturi scrubbers, and aerated tanks (mechanical or diffused aeration). Other types of groundwater treatment equipment include equalization tanks, oil/water separators, and clarifiers.

3.10.1.3 Low Temperature Thermal Adsorbers

Soils or sludges are charged to a rotary kiln unit, heated to a minimum temperature of 400 ^{O}F to 1000 ^{O}F. Volatile organic compounds (VOC), other volatilized contaminants, heavy metals (arsenic, beryllium, cadmium, chromium lead, mercury, nickel) and particulates exit the exhaust stream of the kiln.

3.10.1.4 Exsitu Aerobic Treatment Systems

Soils or water contaminated with VOC are placed in a container, covered bed, or similar apparatus, and air is blown through the container to enhance aerobic digestion of contaminants. The oxygen provided promotes the growth of indigenous microoganisms that subsequently biodegrade the VOC to carbon dioxide and water.

3.10.1.5 Tank Cleaning and Degassing

Tank cleaning involves removing and treating sludges from empty petroleum storage tanks. Prior to removing the sludges, they are treated to make them pumpable. This treatment may consist of mixing in a lighter oil, such as Number 2 Fuel Oil, or stirring up the sludges with pressurized water or by mixing in air already in the tank. The removed sludges are typically forwarded to a mechanical separator to remove solids. They are then sent to either an oil/water separator, centrifuge, or other type of separator. Typically, three streams exit the process: oil stream, water stream, solids stream. The oil stream usually can be rerefined as a method of reuse. The water stream usually can be charged to a wastewater treatment system. The solid stream is typically disposed offsite.

Tank degassing involves the purging of a vessel. The vessel can be a tanker truck or a storage tank. Gases used for the purging include, but may not be limited to, nitrogen and air. The purging is done to ready the vessel for the storage of another type of gas.

3.10.2 SOTA Performance Levels

3.10.2.1 Peformance Levels

The SOTA performance levels are outlined in Tables 1, 2, and 3.

- **Table 1:** This table covers soil vapor extraction systems (SVES), air stripping towers (AST)/other groundwater treatment equipment, exsitu aerobic treatment systems, tank cleaning and degassing systems used to process soils, water, sludges, or waste gases contaminated with commercial petroleum products. The commercial petroleum products include, but are not limited to, gasoline, kerosene, jet fuel, and Numbers 1 through 6 fuel oils.

- **Table 2:** This table covers soil vapor extraction systems (SVES), air stripping towers (AST)/other groundwater treatment equipment, exsitu aerobic treatment systems, tank cleaning and degassing systems used to process soils, water, sludges, or waste gases contaminated with non-petroleum substances.

- **Table 3**: This table covers low temperature thermal desorbers (LTTD) used to process soils contaminated with petroleum and non-petroleum hydrocarbons, chlorinated hydrocarbons, and heavy metals.

3.10.2.2 Listing of Available Technologies

<u>Volatile Organic Compounds</u>

Thermal Oxidizer - 1500 degrees Fahrenheit (F) at 0.5 second residence time, as a minimum operating temperature and residence time.

Catalytic Oxidizer - Temperature and residence time required as per manufacturer's specifications.

Activated Carbon Adsorption - A minimum of two carbon adsorption units in series.

Internal Combustion Engine - controlled with two catalytic converters in series and auxiliary fuel.

<u>Hydrogen Chloride</u> - Wet scrubber (packed tower, venturi, or tray), or dry scrubber with lime injection, followed by a baghouse (fabric filter).

<u>Carbon Monoxide</u> - Thermal Oxidizer, Catalytic Oxidizer, Internal Combustion Engine

Table 1
SOTA Performance Levels For SVES, AST/Other Groundwater Treatment Equipment, Exsitu Aerobic Treatment Systems, Tank Cleaning And Degassing Systems For Commercial Petroleum Contamination
(Gasoline, Kerosene, Jet Fuel, Numbers 1 Through 6 Fuel Oils)*

CONTAMINANT(S)	CONTROL DEVICE(S)	PERFORMANCE LEVEL
VOC	Combustion Devices Such As: Thermal Oxidizer, Catalytic Oxidizer, Internal Combustion Engine	98% minimum control efficiency or no more than 10 ppmv of VOC expressed as equivalent CH_4, corrected to 7% O_2. For O_2 concentration greater than 14%, no more than 5 ppmv of VOC expressed as equivalent CH_4, uncorrected for O_2, when the concentration limit applies.
VOC	Carbon Adsorption Unit	95% minimum control efficiency or no more than 25 ppmv of VOC, expressed as equivalent CH_4
Carbon Monoxide-**	Combustion Devices other than Internal Combustion Engines	No more than 100 ppmv corrected to 7% O_2; at concentrations greater than 14% O_2, 50 ppmv, uncorrected.
Carbon Monoxide-**	Internal Combustion Engine	no more than 300 ppmv corrected to 7% O_2; at concentrations greater than 14% O_2, 150 ppmv, uncorrected.
Other Products of Combustion (particulates, nitrogen dioxide, sulfur dioxide)-**	Thermal Oxidizer, Catalytic Oxidizer, Internal Combustion Engine	Use natural gas, propane, or electricity as the auxiliary fuel. If gasoline, kerosene, or commercial fuel oil is used, then limits will be set on a case-by-case basis.

*-Table 1- Concentration levels are not measured on a dry basis. This is to facilitate the sampling and analysis at these sites. Also, all VOC and CO concentration levels are based on one-hour averages.

**- Products of combustion must be addressed only when a thermal control device is used or when another type of combustion is taking place.

NOTE TO TABLE 1: For the removal and treatment of sludges from petroleum storage tanks, a vapor return system shall be SOTA if this design is preferred by the applicant. The vapor return system may vent all exhaust streams from the sludge/tank bottom process equipment to the tank that is having its bottom sludge removed. This is acceptable for processes conducted at ambient temperatures (less than 100 degrees Fahrenheit), where separation of the phases of the sludges take place through mechanical processes.

Table 2
SOTA Performance Levels For SVES, AST/Other Groundwater Treatment Equipment, Exsitu Aerobic Treatment Units, And Tank Cleaning And Degassing Systems For Non-Petroleum Contaminated Sites -*

CONTAMINANT(S)	CONTROL DEVICE(S)	PERFORMANCE LEVEL
VOC	Combustion Devices Such As: Thermal Oxidizer, Catalytic Oxidizer, Internal Combustion Engine	98% minimum control efficiency, or no more than 10 ppmvd of VOC, expressed as equivalent CH_4, corrected to 7% oxygen. For O_2 concentration greater than 14%, no more than 5 ppmv dry of VOC expressed as equivalent CH_4, uncorrected for O_2, when the concentration limit applies.
VOC	Carbon Adsorption Unit	95% minimum control efficiency or no more than 25 ppmvd of VOC, expressed as equivalent CH_4
Carbon Monoxide-**	Thermal Oxidizer and Catalytic Oxidizers	no more than 100 ppmvd corrected to 7% O_2; at concentrations greater than 14% O_2, 50 ppmvd, uncorrected.
Carbon Monoxide-**	Internal Combustion Engine	no more than 300 ppmvd corrected to 7% O_2; at concentrations greater than 14% O_2, 150 ppmvd, uncorrected.
Other Products of Combustion (particulates, nitrogen dioxide, sulfur dioxide)-**	Thermal Oxidizer, Catalytic Oxidizer, Internal Combustion Engine	Use natural gas, propane, or electricity as the auxiliary fuel. If gasoline, kerosene, or commercial fuel oil is used, then limits will be set on a case-by-case basis.
Hydrogen chloride-***	Scrubbers	minimum 98% control efficiency, or no more than 50 parts per million by volume, corrected to 7% O_2, in the wet flue gas

*- All concentrations are on a dry basis (except for HCl), because, unlike petroleum only contamination, these waste streams are more variable in nature and need to be more closely monitored. Also, all VOC, CO, and hydrogen chloride concentration levels are based on one hour averages.

**-Products of combustion must be addressed only when a thermal control device is used or when another type of combustion is taking place.

***-Hydrogen chloride is generated when a chlorinated hydrocarbon is charged to a thermal control device.

Table 3
SOTA Performance Levels For Low Temperature
Thermal Desorber Used To Process Soils Contaminated With Petroleum And Non-Petroleum Hydrocarbons, Chlorinated Hydrocarbons, And Heavy Metals*

CONTAMINANT	**PERFORMANCE LEVEL**
Particulates, including Arsenic, Beryllium, Cadmium, Chromium, Lead, Nickel-**	no more than 0.02 gr/dscf, corrected to 7% O_2
VOC	minimum 98% control efficiency, or no more than 10 ppmvd of VOC, expressed as equivalent CH_4, corrected to 7% oxygen
Carbon Monoxide	no more than 100 ppmvd, corrected to 7% O_2, or at oxygen concentrations greater than 14%, 50 ppmvd
Hydrogen Chloride-***	minimum 98% control efficiency, or no more than 50 parts per million by volume, corrected to 7% O_2, in the wet flue gas
Sulfur Oxide(s)	minimum 90% control efficiency, or no more than 30 parts per million by volume, dry basis, corrected to seven percent oxygen
Nitrogen Oxide(s)	case-by-case, Lowest Achievable Emission Rate (LAER) Technology Required if the emissions are over 25 ton per year
Mercury	no more than 28 micrograms per cubic meter, dry basis, corrected to seven percent oxygen

*-For a listing of available control devices, please refer to Section 3.10.2.2. All VOC, carbon monoxide, hydrogen chloride, and sulfur oxide(s) concentration levels are based on one hour averages.

**- Heavy metals have to be addressed additionally by a risk assessment

***-Hydrogen chloride is generated when a chlorinated hydrocarbon is charged to a thermal control device.

<u>Products of Combustion (Nitrogen Oxides, Sulfur Oxides, Particulates) from thermal</u>

control equipment - Use of natural gas, propane, or electricity as fuel in the Thermal Oxidizer, Catalytic Oxidizer, or Internal Combustion Engine. If gasoline, kerosene, or commercial fuel oil is used, then limits will be set on a case-by-case basis.

Particulates, including heavy metals (i.e. arsenic, beryllium, cadmium, chromium, lead, nickel)- baghouse (fabric filter). NOTE: a cyclone is commonly used to remove the larger particulates prior to the primary particulate control device for Low Temperature Thermal Desorbers.

Mercury - carbon injection upstream of particulate control device (i.e. baghouse), or two activated carbon canisters in series

Sulfur Oxide(s) - Wet scrubber (packed tower, venturi, or tray), or dry scrubber with lime injection, followed by a baghouse (fabric filter).

Removal and processing of sludge bottoms from petroleum storage tanks - All process equipment which may include, but is not limited to, centrifuges, separators, and screeners, is enclosed and the exhaust stream is vented back to the tank that is having the sludge removed. The tank shall either have a fixed roof with a conservation vent or have a floating roof. No fugitive emissions should occur during the processing and the processing shall be conducted at ambient temperatures.

3.10.3. Technical Basis and References

The SOTA performance levels were developed from several sources. A search of the New Jersey Air Pollution Control (APC) Permit and Certificate files was conducted concurrently with a review of stack test results of permitted NJ sources. Information concerning site remediation sources in other states, literature sources, as well as vendor guarantees were evaluated. The literature sources included documents that outlined performance results for LTTDs and papers from the “1996 International Conference on Incineration and Thermal Treatment Technologies”.

A major contaminant emitted from nearly all site remediation activities is VOC. VOC is volatilized or evaporated off of the wastes (water, soils). For Thermal Control Devices (thermal oxidizers, catalytic oxidizers, internal combustion engines) a VOC performance level of 98 percent control efficiency, or 10 parts per million by volume, as equivalent methane, dry basis, corrected to 7% oxygen has been established. The Department has issued Air Pollution Control (APC) Permits for 3 SVES, 4 LTTD, and 4 AST/Groundwater Treatment Systems which achieved this level. The review of data from other states showed one SVES and 3 LTTDs which achieved the “98%/10 ppmv” level. The BACT/LAER Clearinghouse lists 6 sources that achieved the level. A literature source listed 12 individual LTTDs that met the requirement for the thermal control units.

A minimum 95% VOC control efficiency for activated carbon adsorption units has been established. The Department has issued APC Permits for one SVES and one LTTD that demonstrated compliance with the 95% control level. This is consistent with the MACT standard at 40 CFR Part 63, Subpart DD, NESHAP for Off-Site Waste Recovery Operations. The State of Michigan required a 95% control efficiency for activated carbon units. The BACT/LAER Clearinghouse lists two sites whose activated carbon adsorption units' VOC control efficiency exceeded 95%.

Carbon monoxide is generated as a product of incomplete combustion when wastes are thermally treated or when a thermal APC device is used. A low CO level provides confirmation that the VOC are being fully treated and that the thermal APC device is operating properly. Seven New Jersey sources have been stack tested and achieved less than the "100 ppmv" CO emission limit. In other states, two permitted sources and one stack tested source have emissions consistent with the "100 ppmv" CO level. A literature source lists 13 LTTD, each of which emits less than 20 ppmv of CO. CO levels have been established for all operating scenarios, except when an Internal Combustion Engine is used as the thermal control device.

When an Internal Combustion (IC) Engine, followed by two catalytic converters in series, is the control device, a 300 ppmv CO level has been instituted. This CO level has been permitted in California and Arizona, and is consistent with manufacturer's guarantees. Several of these control devices have been permitted in New Jersey for SVES. The IC Engine is primarily used when the exhaust stream has a high VOC concentration level.

Particulate emissions that result directly from the waste treatment operations are emitted from LTTD. LTTD particulate emissions come from the desorber (usually a rotary kiln) when solids are entrained in the exhaust stream. Three New Jersey LTTD units achieved a grain loading of 0.02 gr/dscf or less corrected to 7% oxygen. In another state, one LTTD was permitted at a grain loading of 0.02 gr/dscf corrected to 7% oxygen. A literature source lists 11 LTTDs which met the limit of 0.02 gr/dscf at 7% oxygen . Consequently, the "0.02 gr/dscf at 7% oxygen" performance level has been selected.

Hydrogen chlorine (HCl) is formed when chlorinated VOC is charged to a thermal APC device. The chlorinated VOC reacts with oxygen to produce carbon dioxide, water, and HCl. HCl is soluble in water, which results in this acid gas being controlled by a wet scrubber. Eleven absorption control systems are found on New Jersey site remediation sources. Table 8.2-1 from "Methods Manual for Compliance with the Boiler and Industrial Furnace (BIF) Regulations." lists HCl control efficiencies of ninety-eight percent (98%) or greater for the following equipment: venturi scrubber, dry scrubber/ baghouse, wet scrubber/ionizing wet scrubber, ionizing wet scrubber, and spray dryer/baghouse. Although BIF are not the subject of this Manual, technology transfer to site remediation equipment is appropriate since control of HCl in any exhaust stream depends not on its source, but on its quantity in the stream and the temperature of the stream. HCl control to the 98% level is further supported by the fact that it is highly soluble in water (56.1 g HCL/ 100 g H_2O at 60 F).

Like particulates, heavy metals (arsenic, beryllium, cadmium, chromium, lead, mercury, nickel) will be emitted from LTTD. Many factors determine the uncontrolled emission rates of the metals. These include the temperature the wastes are subjected to, the chloride content of the waste, the waste-processing rate, and the manner in which the wastes are handled. A specific mercury emission level of 28 micrograms per cubic meter, dry basis, corrected to seven percent oxygen has been established. This is the result of mercury's high volatility and low boiling point of 357 degrees Fahrenheit. This conclusion is based on the information provided in "Task Force on Mercury Emission Standard Setting, Volume III, Technical and Regulatory Issues."

Sulfur emissions occur at remediation sites. Air contaminants are generated when sulfur compounds are evaporated off in the treatment process and charged to a thermal control device. The resulting contaminant is sulfur oxide(s) (SO_x). SO_x is also produced when fuel oil is used as fuel in the thermal treatment and control equipment. Two New Jersey LTTDs have incorporated SO_x APC systems. One demonstrated a 99% SO_x control efficiency. The other was permitted at a 90% SO_x control efficiency.

Natural gas, propane, or electricity is recommended to be used as the auxiliary fuel for thermal equipment. These fuels emit less contaminants than fuel oil. For SVES and AST/other water treatment equipment, the emission of particulates, sulfur oxide(s), and nitrogen oxide(s) almost always are generated exclusively from the combustion of the auxiliary fuel.

Processors of the petroleum tank bottom/sludges have the option to cover the treatment equipment and vent the contaminant emissions to the tank. This creates a near "vapor return loop" system, with the only potential emissions occurring at the tank's vent. The tank must have a conservation vent or floating roof. This is reasonable since the tank has been designed and is already permitted to control the types of contaminants emitted from the sludge processing. Also, it provides the contaminants the opportunity to condense in the tank. The on-site tank bottom/sludge processing creates an environmental/pollution prevention benefit. The sludges are separated into three streams: product (solvent/oil) which can be reused, solids, which can be disposed of off-site, and waste water, which can be forwarded to a water treatment system. This is superior to just removing the sludges and disposing them off-site. The installation of the vapor return loop system does not inhibit the processing of the sludges. It should be noted that this option is limited to processes operating at ambient temperatures.

3.10.4 Recommended Review Schedule

It is recommended that the Site Remediation State of the Art Manual be reviewed for modification annually. New types of treatment systems are developed regularly as industry attempts to find more efficient and cost effective ways of cleaning up contaminated sites. This yearly review will give both the Department and the regulated community the opportunity to examine innovations and determine if they represent the current "State of the Art."